Enabling Higher Data Rates for Planetary Science Missions

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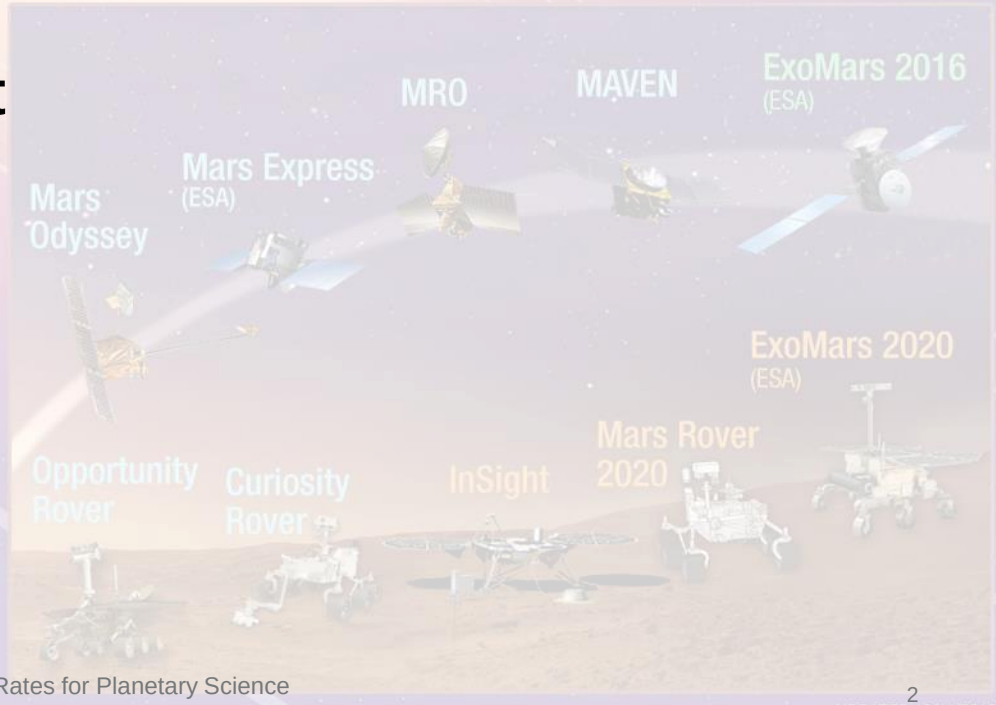
Higher Data Rates and Volumes

- What's been accomplished?
- Why is it important?
- How are we going to do it?
  - All missions
  - Small spacecraft



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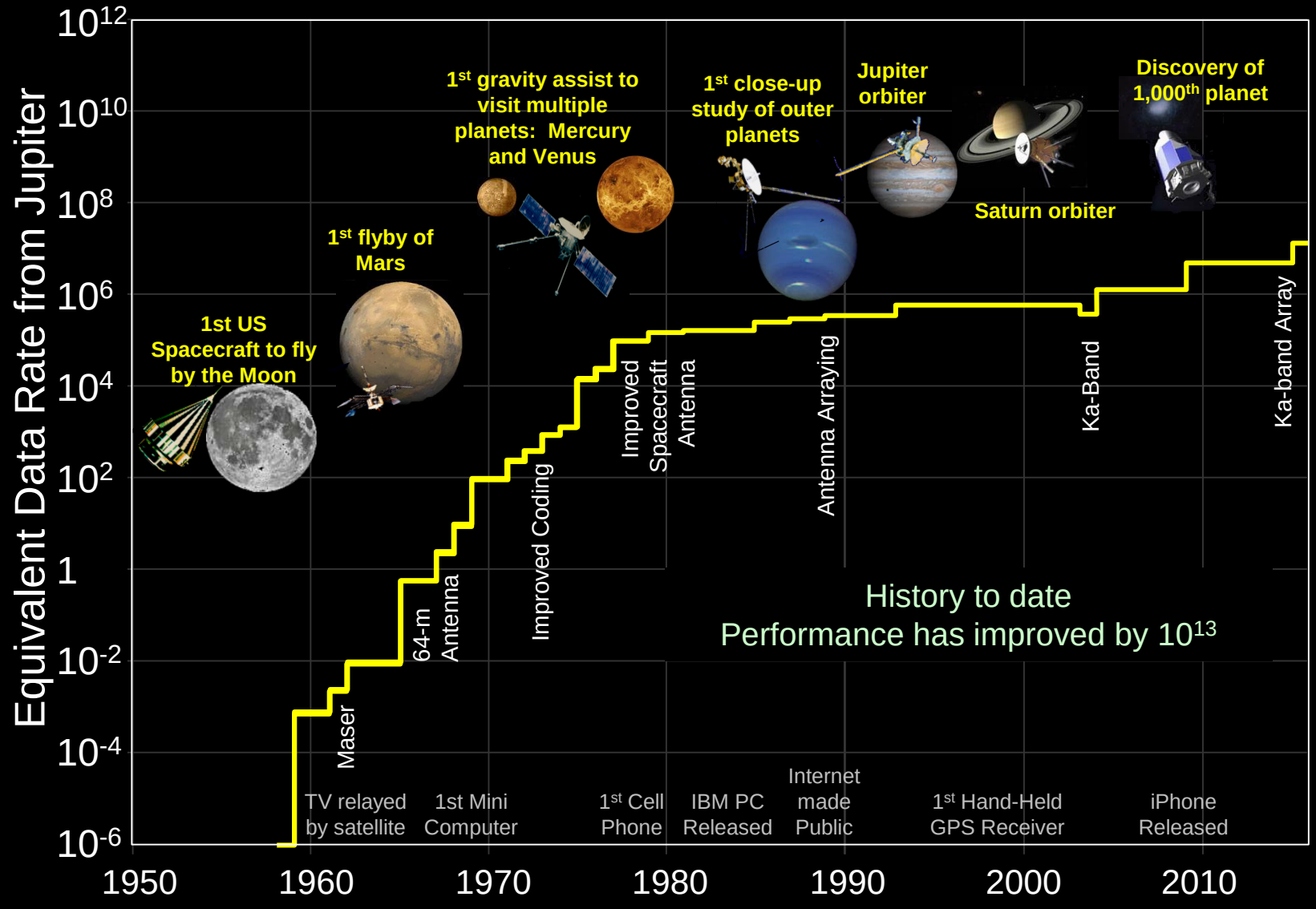
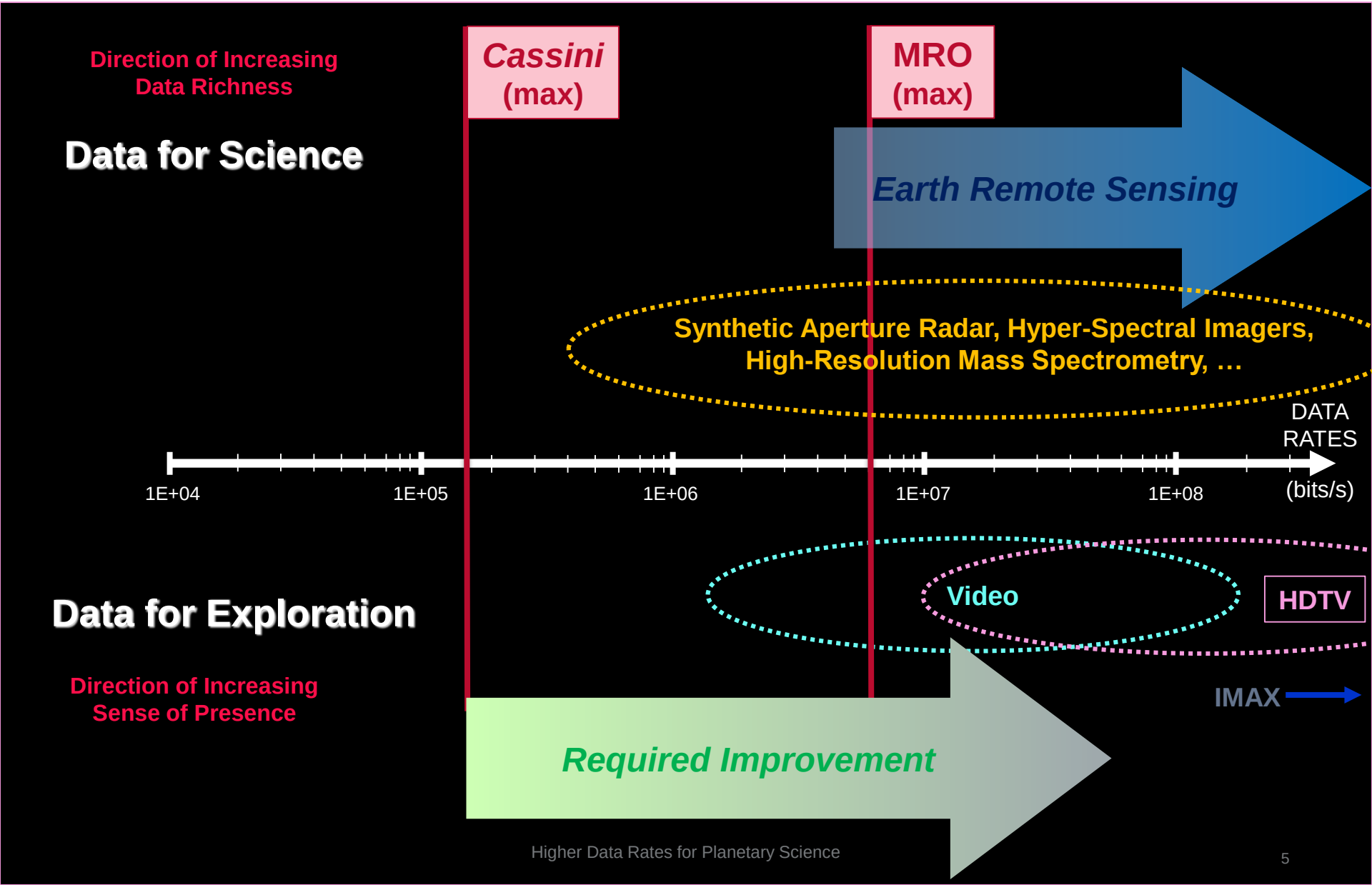
Deep Space Network

History of Planetary Data Transmission Improvements



Remote Sensing at Other Planets as at Earth

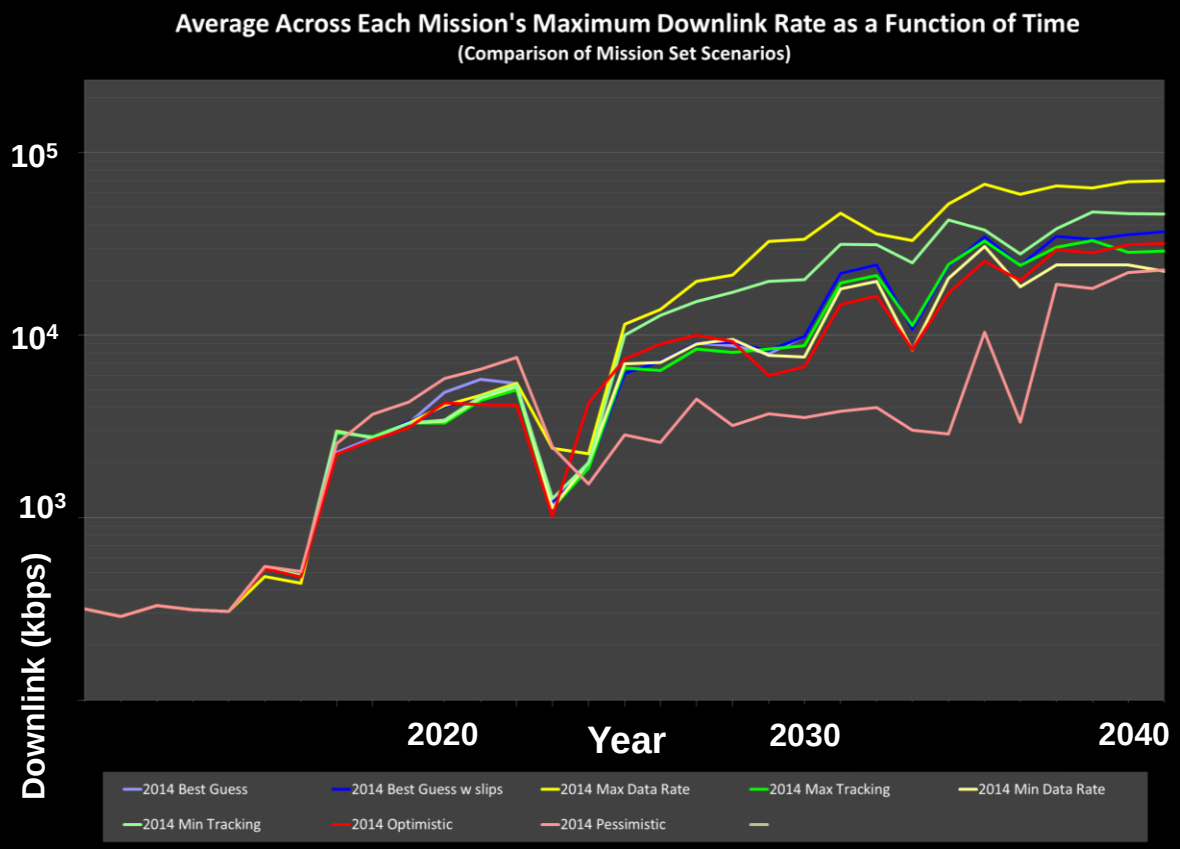


Future Mission Data Rate Trends

Science Directions

- Have visited all major objects in Solar System, Global continuous presence on Mars since 2004
- Trends: Revisit for more intense study, Smaller spacecraft and constellations, Humans beyond LEO

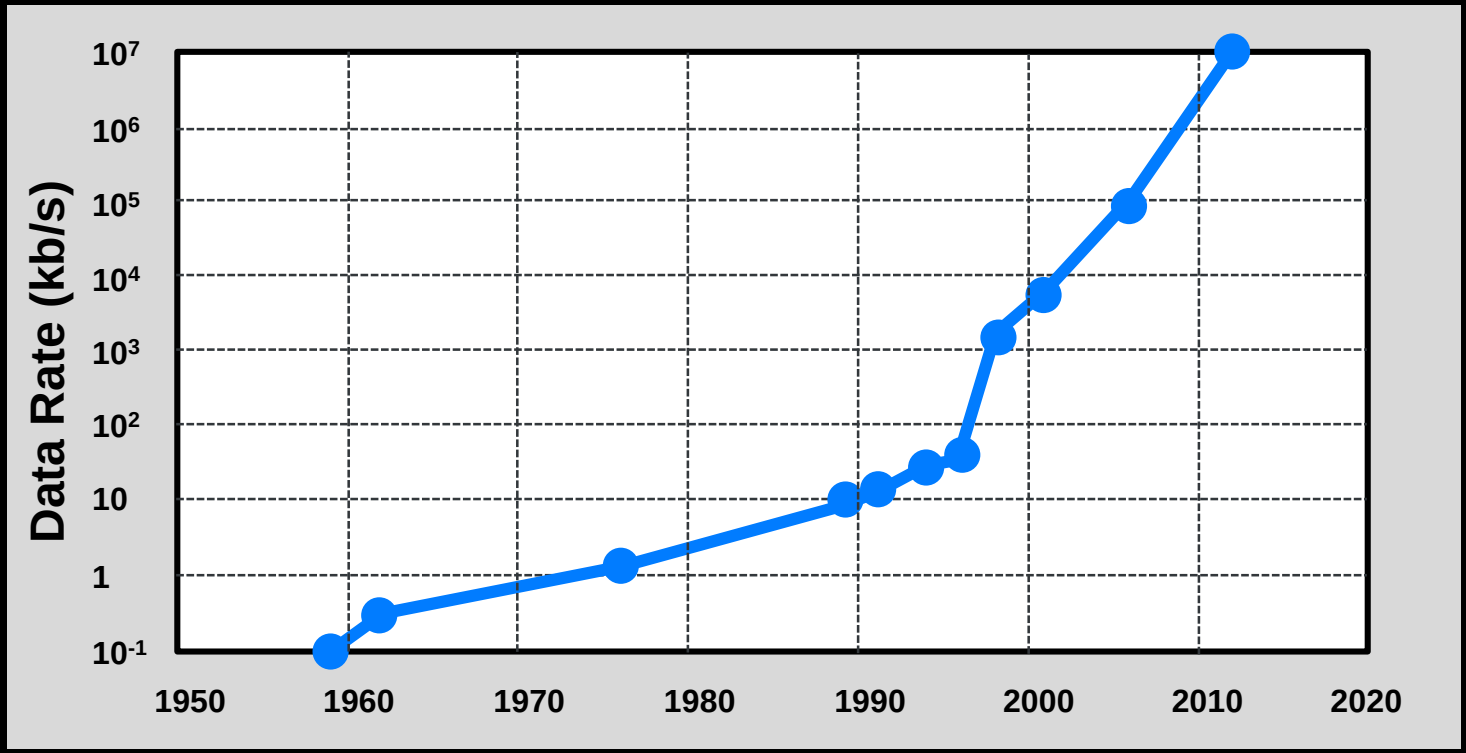
Mission modeling indicates desire for ~ 10× data improvement per decade (at least) through 2040



Internet Communications Trend

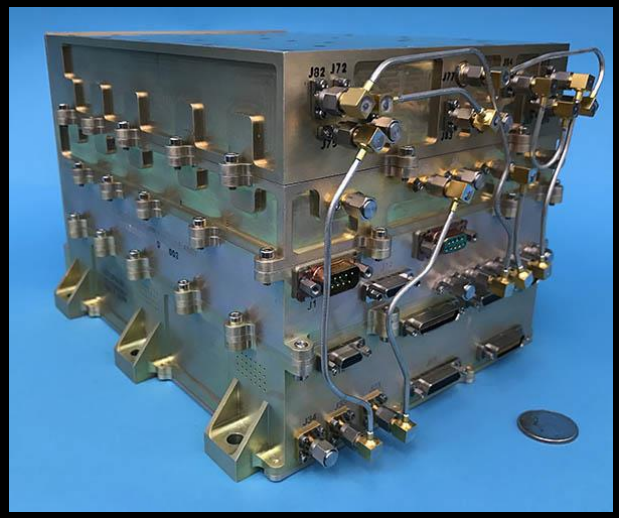
- Consider trend in digital communications since the Internet was invented
- Trend is ~1.3 orders of magnitude per decade

We believe spacecraft data needs will grow similarly – we will use 1.0 order of magnitude per decade

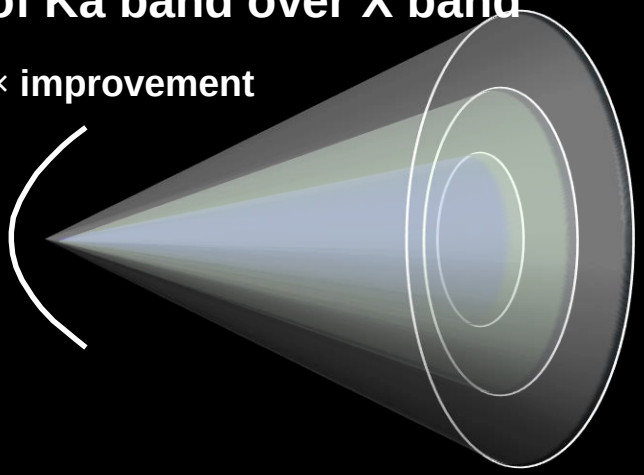


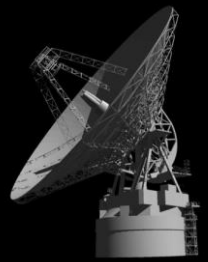
Decade 1: 10× Improvement over Today

- **Remove bottlenecks on spacecraft and DSN**
  - **Universal Space Transponder (UST)**
  - **Common Platform DSN signal processor**



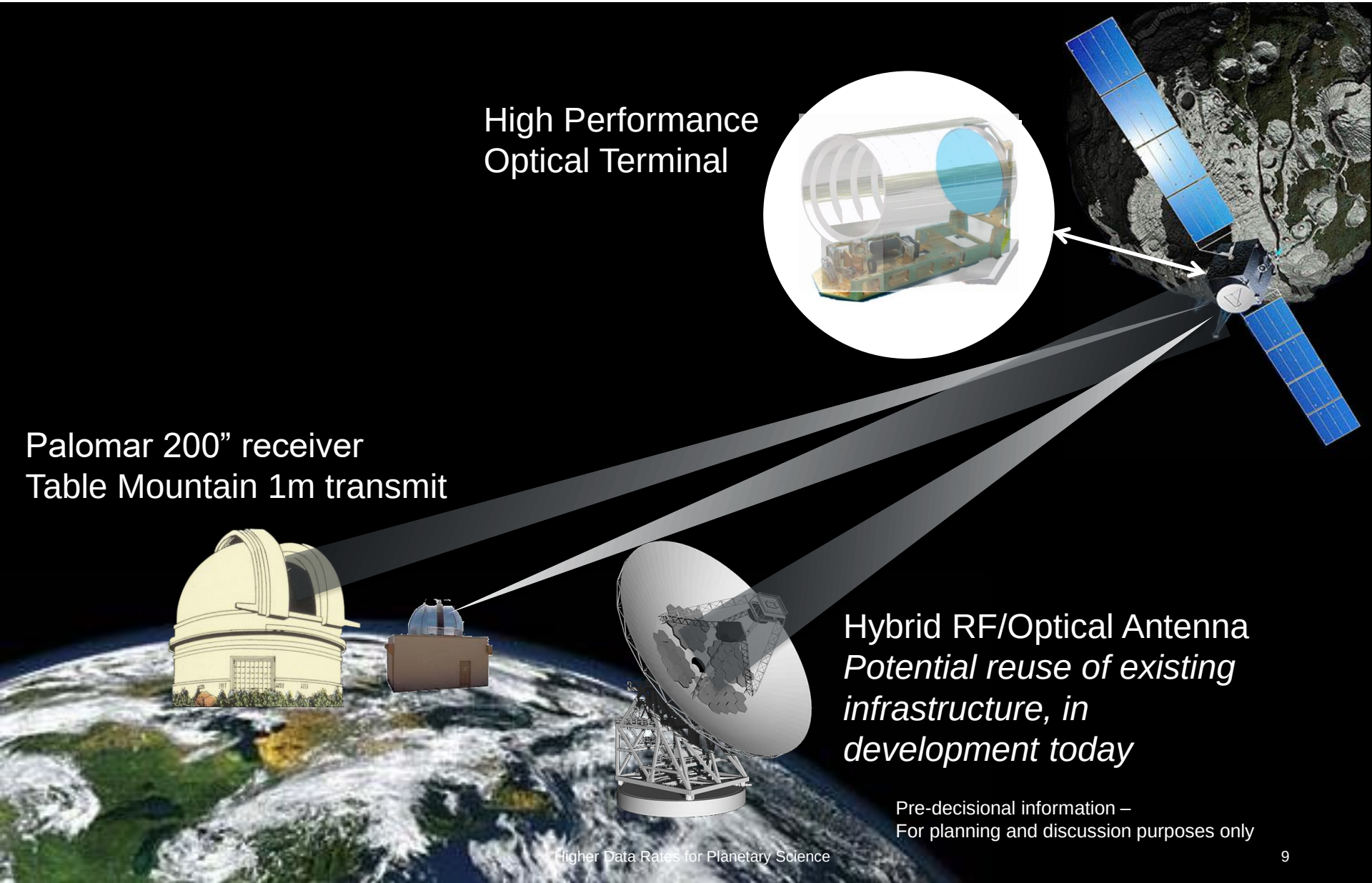
- **Increase use of Ka band over X band**
  - **Factor of ~ 4× improvement**





- **Antenna arraying**
  - **DSN Aperture Enhancement Project emplacing additional 34 m antennas**
  - **Provides backup for 70m capability as well as arraying beyond 70m**

Optical Comm – Planned Psyche Demo

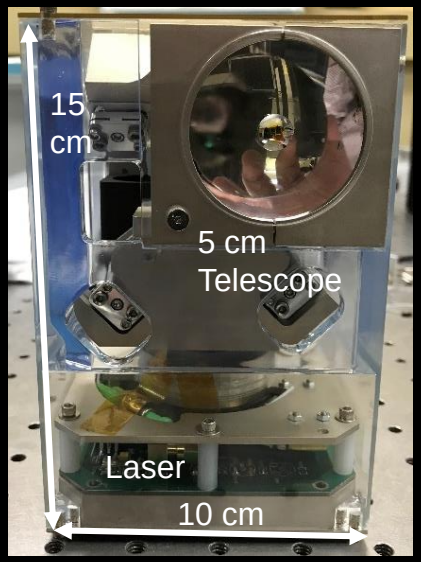


Pre-decisional information –
For planning and discussion purposes only

Deep Space Small Spacecraft Technologies

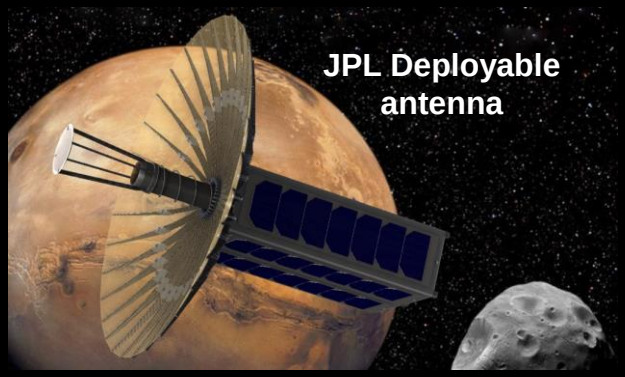
- CCSDS-compatible X-band radio – Ka-band & DTN in development
- 0.5m Ka-band deployable parabolic antenna
  - First flight on RainCube – as radar antenna
- Optical terminals for CubeSats
  - kbps at 2.5 AU using binary pulse-position modulation and polarization modulation (2-PZM)
- Demo of DSN “opportunistic multiple spacecraft per aperture” (OMSPA) completed
  - Provide essentially unlimited number of simultaneously-tracked spacecraft
- Working with universities to create a federated network of ground antennas, based on existing standards

JPL IRIS radio

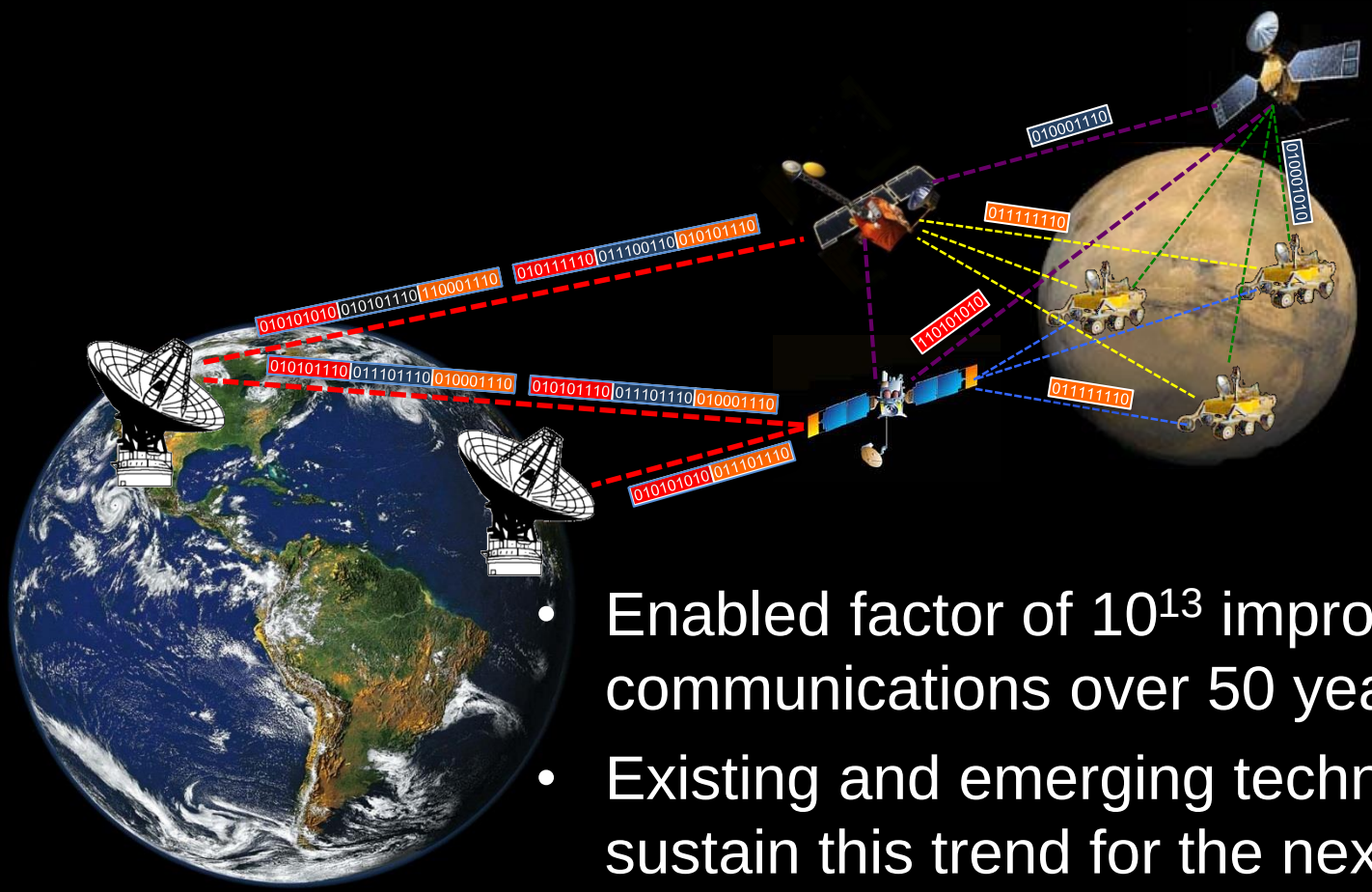


JPL CubeSat optical terminal


Morehead State University 21m Antenna


JPL Deployable antenna

The DSN and the Interplanetary Internet



- Enabled factor of 10^{13} improvement in communications over 50 years
- Existing and emerging technologies will sustain this trend for the next 20 years
- Pushing technologies and techniques to enable higher data rates for SmallSats

Long Term Communications Trend

- **Data gleaned from the Internet suggests ~ 0.34 orders of magnitude per decade**
- **… we all know (feel?) the Information Age has accelerated this**